

VLBI observation of giant radio galaxy J1313+696 at 2.3/8.4 GHz

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Abstract

We report the result of VLBI observation of the giant radio galaxy J1313+696 (4C +69.15) at 2.3/8.4 GHz, only the core component of the giant radio galaxy was detected in the VLBI observation at the dual frequencies. The result shows a steep spectrum core with $\alpha = -0.82$ ($S \propto \nu^\alpha$) between 2.3 GHz and 8.4 GHz. The steep spectrum core may be a sign of renewed activity. Considering also the upper limit flux density of 2.0 mJy at 0.6 GHz from Konar et al. 2004 the core has a GHz-peaked spectrum, implying that the core is compact and absorbed. Further high resolution VLBI observations are needed to identify if the steep spectrum core is consisting of a core and steep spectrum jet.

Keywords Active galactic nuclei; Giant radio galaxy; 4C +69.15

1 Introduction

It's known that the large radio sources are classified into two types i.e. FRI and FRII-type according to the morphology of the radio sources. Among the large radio sources, the radio galaxies whose lobes span a (projected) distance of above 1 Mpc are called giant radio galaxies (GRGs), and the majority of them are FRII sources (Schoenmakers et al. 2001). A small number of the large extended sources consisting of a pair of double lobes have been called double-double radio galaxies (DDRGs), and the observed structures of

DDRGs suggest recurrent or interrupted central activity as the origin of these sources (Schoenmakers et al. 2000a; Saikia et al. 2006). The large radio sources have been observed with telescopes or arrays at relatively low resolution but not well observed with the very long baseline interferometry (VLBI). The VLBI observation is able to identify the core of the large radio sources at high resolution. We have included the GRG J1313+696 in our sample of VLBI observation with the European VLBI Network (EVN) at dual frequency 2.3/8.4 GHz simultaneously.

2 Observation and data reduction

The VLBI observation was carried out on 2002 June 4 at 2.3/8.4 GHz using the Mark4 recording system with a bandwidth of 16 MHz in right circular polarization. The EVN antennae in this experiment were Effelsberg, Wettzel, Medicina, Noto, Matera, Onsala, Yebes, Urumqi and Shanghai. All station gives useful fringes. The snapshot observations of 12 target sources in a total of 24 hours of observing time have been done (Xiang et al. 2005). The source J1313+696 was included in the source sample and observed in total of about 1.5 hours. The calibrator source OQ208 was used in the observation. The data correlation was completed at the Joint Institute of VLBI in Europe (JIVE) in January 2003.

The Astronomical Image Processing System (AIPS) has been used for editing, a-priori calibration, fringe-fitting, self-calibration and imaging. The ANTAB file was checked and corrected according to the EVN status table, station feedback and the observation log-files. The AIPS task 'UVCRS' was used to correct the estimated antenna gains of Wettzel and Matera antenna before the fringe-fitting, since their antenna gains were not available in the EVN status table. The errors of the flux densities were estimated to be in uncertainty

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of 10% according to the calibrator source OQ208 in the final VLBI images.

3 Result and discussion

J1313+696 (B1312+698, DA340, 4C +69.15, $z=0.106$), is an FRII type giant radio galaxy. In VLA observation at 1.4 GHz the emission from the core to the lobes forms a continuous bridge in SE-NW direction (Lara et al. 2001), the GMRT observation at 605 MHz shows a similar structure (Konar et al. 2004). But at 4.9 GHz only the core and the lobe extremes are detected with the VLA (Lara et al. 2001), and the core position is consistent with the position of the associated galaxy. The source was not classified as a DDRG according to the definition of Schoenmakers et al. (2000a) which an inner pair of edge-brightened lobes should be detected.

The VLBI images (Fig. 1, Fig. 2) of J1313+696 at 2.3/8.4 GHz show a point source. We checked the position of the point source in the VLBI maps with the VLA images at 1.6 and 5 GHz (Lara et al. 2001), confirmed that the VLBI point source is the core of J1313+696 in the VLA images. We collected the core flux densities of J1313+696 from our data and literature as shown in Fig. 3, the error bars are 1σ (per beam) from our data and the literature. The source flux densities in the VLBI observation at 2.3 GHz and 8.4 GHz are 7.5 ± 1.1 mJy and 2.6 ± 0.2 mJy respectively. It is 10.2 mJy at 1.4 GHz and 3.8 mJy at 4.9 GHz in Lara et al. (2001), and 6 mJy at 2.7 GHz in Saunders et al. (1987). It is 7 mJy at 1.4 GHz, 4.3 mJy at 4.9 GHz, and an upper limit of 2 mJy at 605 MHz in Konar et al. (2004). The spectral index between 2.3 and 8.4 GHz in the VLBI observation is -0.82 (we use $S \propto \nu^\alpha$). The spectral index from the collected data above 1.4 GHz can be fitted linearly (Fig. 3) with $\alpha = -0.78 \pm 0.03$. It is interesting that this value is consistent with the spectral indices of the east, west lobe of J1313+696 (Schoenmakers et al. 2000b). However, because an upper limit 2 mJy at 605 MHz was estimated by Konar et al. (2004) the integrated spectrum in Fig. 3 can also be an inverted spectrum which peaked around 1.4 GHz. We note that the 1.4 GHz core flux (10.2 mJy) from Lara et al. (2001), might be overestimated due to contamination of diffuse emission. As Lara et al. mentioned, for this core the ratio peak/total < 0.8 . An ideal point source should have the ratio peak/total ~ 1 . The core is sitting on top of a diffuse emission, as is evident from the map in Lara et al.. Whereas, the measurement of Konar et al. (2004) has less contamination as they re-mapped the field with lower uv-cut-off to lose the diffuse flux and get the core flux as correct as possible.

Konar et al. (2004) have discussed the steep-spectrum cores (SSCs, $\alpha_{core} < -0.5$) of GRGs, in their sample at least 3 out of 17 sources show SSCs. In Lara et al. (2004) sample a compact radio core was detected at 4.9 GHz with VLA in all sources, with an average spectral index of 0.07 ± 0.41 for FRII and -0.24 ± 0.52 for FRI sources; hence FRIs seem to have more SSCs than FRIIs according to the averaged spectral indices. However, Lara et al. (2004) explained that the core spectral index in FRIs suffers from more contamination from the steeper jet emission than in FRIIs. In Konar et al. (2004) sample, 3 FRII-type sources have been suggested to have SSCs besides J1313+696. They suggested that SSC is preferentially occurred in giant radio galaxies, and SSC is related to the interrupted activity of GRGs. Schoenmakers et al. (2000b) found a polarized component of J1313+696 near but not at the core position, they suggested it is a jet component.

The VLBI images of J1313+696 show a point source, not as expected to show a core-jet, but reveal a steep spectrum core which may imply a renewed jet in the core. Considering the upper limit flux density at 605 MHz the core of the J1313+696 has a GHz-peaked spectrum (GPS), indicating the core is very compact and absorbed at lower frequency. We estimated an upper limit of the core size at 8.4 GHz with the beam size of our VLBI map, it is 3.8 pc (in $H_0 = 71 \text{ km s}^{-1} \text{ Mpc}^{-1}$, $\Omega_m=0.27$, and $\Omega_{vac}=0.73$ cosmology). Another example is the DDRG B1834+620, its core shows a steep spectrum at higher frequencies with spectral index the same as that of lobes, and the core spectrum is inverted at lower frequencies, showing a GPS shape (Schoenmakers et al. 2000c). Konar et al. (2008) found a GPS core in the GRG J1155+4029 with GMRT and VLA observations.

4 Summary

We present the first VLBI images of the giant radio galaxy J1313+696 at 2.3/8.4 GHz, the VLBI result shows a steep spectrum core of J1313+696 with $\alpha = -0.82$ between 2.3 GHz and 8.4 GHz. The steep spectrum core may be a sign of renewed activity. The core has a GHz-peaked spectrum, implying that the core is compact and absorbed. Further high resolution VLBI observations are needed to identify if the steep spectrum core is consisting of a core and steep spectrum jet.

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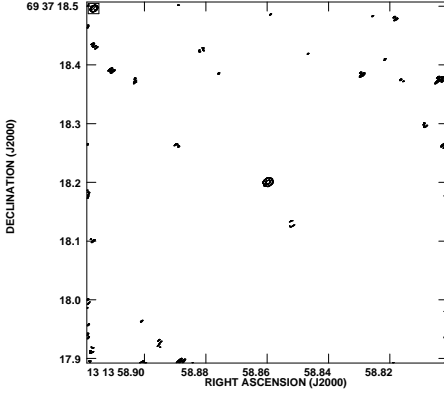


Fig. 1 VLBI image of J1313+696 at 2.3 GHz, the restoring beam is 12.9×9.0 mas with PA -49° , the peak is 7.7 mJy/beam, the first contour is 3 mJy/beam which is 3σ . The contour levels are increased by a factor of 2.

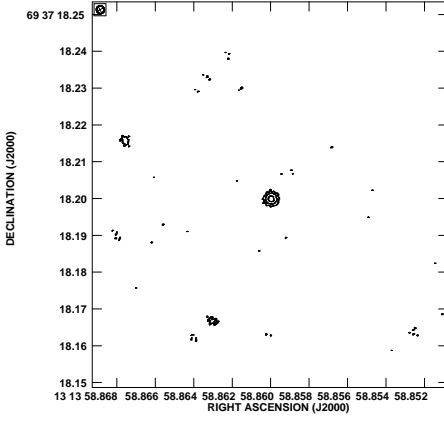


Fig. 2 VLBI image of J1313+696 at 8.4 GHz, the restoring beam is 2.1×2.0 mas with PA 28° , the peak is 2.7 mJy/beam, the first contour is 0.5 mJy/beam which is 3σ . The contour levels are increased by a factor of 2.

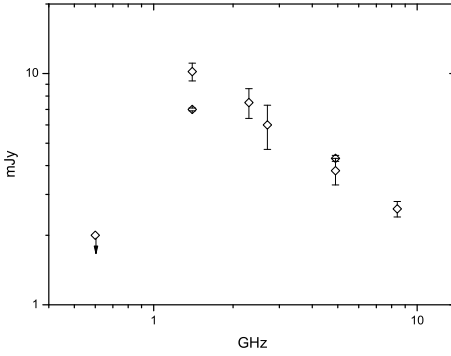


Fig. 3 Spectrum of the core component of J1313+696 at 0.6, 1.4, 2.3, 2.7, 4.9, and 8.4 GHz. Data are from Konar et al. (2004), Lara et al. (2001), Saunders et al. (1987) and this observation.

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